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Incisor analysis technique to predict the gender of black bears damaging trees

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Abstract

Black bear (*Ursus americanus*) feeding on tree cambium is a forest management concern in the Pacific Northwest. Predicting the gender of bears foraging on cambium could provide valuable insight for damage management by focusing management on depredating bears. Equations were generated from dental impressions taken from live bears captured in western Washington State to classify the gender of bears that left incisor grooves on freshly damaged trees. Males had wider primary, I1, (0.55 cm ± 0.01, $P = 0.04$) and secondary, I2, upper incisors (0.67 cm ± 0.01, $P = 0.001$) than female bears (0.49 cm ± 0.02 and 0.58 cm ± 0.01, respectively). The widths of individual incisor grooves in the cambium of trees in western Washington were measured and compared to dental measurements from live bears, revealing that females damaged 90% (88 of 98 trees with I1 impressions; 66 of 73 trees with I2 impressions) of trees sampled during 1996. Damage management programs should target female bears rather than indiscriminately applied to all bear age-gender classes. Published by Elsevier Science Ltd.

1. Introduction

Black bear (*Ursus americanus*) damage to conifers from feeding on cambium is a concern of commercial forest managers in the Pacific Northwest (Maser, 1967; Poelker and Hartwell, 1973; Mason and Adams, 1989; Kanaskie et al., 1990; Noble, 1994; Witmer et al., 2000). Bears use their claws and teeth to peel bark in vertical strips from trees and consume the underlying cambium by scraping it with their incisors (Pierson, 1966; Schmidt and Gourley, 1992; Ziegltrum, 1994; Stewart, 1997). Bears feeding on cambium can damage as much as 70% of a stand (Schmidt, 1987). Predicting the gender and age class of bears feeding on cambium could result in a better understanding of black bear foraging ecology and aid management of tree damage.

Maser (1967) observed that individual tooth marks on the cambium of damaged trees varied in width, corresponding to the width of individual incisors. The gender of plains pocket gophers (*Geomys bursarius*) can be determined from the width of incisors (Case and Sargeant, 1982). Because of sexual dimorphism in black bear body size, incisor measurements may aid in identification of the gender causing damage. The objective of this study was to predict gender of bears foraging on tree cambium by comparing bear incisor widths to incisor grooves in the cambium of damaged trees.

2. Study area and methods

This study was conducted on 2 areas in western Washington State. The Snoqualmie Study Area (King County, 121° 42′ W, 47° 42′ N) is on the west slope of the Cascade Mountains and managed by private timber companies. Elevations range from 116 to 1160 m. Vegetative associations include the western hemlock (*Tsuga heterophylla*) and the Pacific silver fir (*Abies amabilis*) zones (Franklin and Dyrness, 1973). Precipitation (123 cm) occurs mainly between October and May (Olson and Hoffman, 1979). The Olympic Study Area (Grays Harbor County, 123° 45′ W, 47° 15′ N) is in the southwestern portion of the Olympic Peninsula. The area is intensively managed for timber and occurs in the western hemlock vegetative zone. Elevations range from sea level to 997 m with annual precipitation of 380 cm.

Bears were captured, immobilized, and radio-transmittered as part of a long-term bear-forestry relations

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Table 1
Comparison of upper incisor width (I1, I2) by gender of black bears captured on the Snoqualimie study area, the Olympic study area, and the two study areas combined, Washington, 1996–1997

Gender and incisor	Snoqualmie area			Olympic area			Combined areas		
	N	Mean width (cm)	*SE*	*N*	Mean width (cm)	*SE*	*N*	Mean width (cm)	*SE*
Females									
I1	10	0.48	0.02	4	0.52	0.02	14	0.49	0.02
I2	10	0.58	0.01	4	0.59	0.02	14	0.58	0.01
Males									
I1	9	0.54	0.02	9	0.55	0.02	18	0.55	0.01
I2	9	0.67	0.02	9	0.67	0.02	18	0.67	0.01

study (Stewart et al., 1999). Denture-quality clay impressions were made of the upper and lower incisors of captured bears at the time of immobilization. Incisor dental impressions were taken from 9 male and 10 female bears captured between May and June 1996 on the Snoqualmie study area and from 9 male and 4 female bears captured on the Olympic Peninsula between May and June 1997. The bears were of a wide range of ages with both adult and subadult bears of each sex represented. Male bears were from 1–11 years old with 8 adults and 10 subadults ($\leqslant 3$ years old). Females were from 1–10 years old with 9 adult and 5 subadults ($\leqslant 2$ years old).

Dental molds were produced from the clay impressions using a commercial dental stone material. The width of each incisor was measured from molds, to the nearest 0.01 cm, with vernier calipers at the tooth's distal or contact area. We tested for significant differences ($p \leqslant 0.05$) in average width of each pair of primary (I1) incisors among gender and between the two study sites using a two-factor ANOVA (SAS Institute Inc., 1996). We then repeated this analysis for the secondary (I2) incisors. Width of tertiary (I3) incisors was not measured because of the rare occurrence of I3 grooves in the cambium of freshly damaged trees.

The widths of I1 and I2 incisors were each graphed on cumulative percentage curves to classify females and males groups. For I1, measurements $\leqslant 0.52$ cm were classified as female and $\geqslant 0.53$ cm as male. For I2, measurements $\leqslant 0.61$ cm were classified as female and $\geqslant 0.62$ cm as male. These classifications were used to predict the gender of bears from which tooth groove measurements were obtained from the cambium of damaged trees.

Ground searches to locate freshly damaged trees (< 30 days old, determined by the presence of bright yellow non-oxidized cambium) focused around ground and aerial radio telemetry locations for 10 male and 10 female bears on the Snoqualmie study area during May–June 1996 (Stewart, 1997). Only freshly damaged trees early in the damage season were used for tooth groove measurements to help avoid potential biases such as shrinkage of the incisor grooves as the exposed cambium dried. Damage searches occurred within an 8-ha area and were conducted until > 25 damaged stems/ha were counted (Noble, 1994). Vernier calipers were used to measure the width of incisor grooves in the cambium of freshly damaged trees to the nearest 0.01 cm. Incisor grooves were distinguished into incisor pairs (I1, I2, I3) based on symmetry observed in incisor widths of captured bears. The I1 grooves in the cambium were used as a starting point for identifying I2 and I3 teeth. If two adjacent grooves could not be classified as both I1 based on width and standard deviations from dental mold measurements, the sample was discarded due to uncertainty.

3. Results

Tooth impressions of bears from the two study areas were pooled by gender to provide a larger sample size because no difference was detected between study areas ($P \geqslant 0.20$) and there was no interaction between gender and study area ($P \geqslant 0.61$; Table 1). Male bears had wider I1 ($P = 0.04$) and I2 ($P = 0.001$) upper incisors than female bears (Table 1). Lower incisor measurements were not compared due to the rareness of lower incisor grooves in trees. There were no differences between subadult ($\leqslant 2$ years old) and adult females ($P = 0.17$ for I1 and $P = 0.43$ for I2) nor between subadult ($\leqslant 3$ years old) and adult males ($P = 0.19$ for I1 and $P = 0.19$ for I2). Therefore, age classes were pooled within genders.

Fresh damage was detected on 46 of 96 (48%) plots investigated for damage. Male bears were more difficult to locate than females because of larger home ranges (60.7 vs. 11.3 km^2, G. Koehler, unpubl. data). This resulted in 24 radio telemetry location plots investigated as possible male damage sites and 72 plots associated with female locations (Stewart, 1997). It should be noted, however, that non-radio-transmittered bears of either sex and of varying ages could easily have been present in any of these areas.

Incisor grooves in cambium were easily distinguished as upper or lower incisor grooves based on point of entry into the cambium and scrape direction (up or down). Incisor grooves indicated upper incisors were used predominantly. Therefore, analyses included only upper incisors. Of incisor groove measurements taken from 98 trees, only 7 cases were classified as unknown gender because I1 and I2 groove measurements indicated different genders (Table 2).

Table 2
Predicted gender of black bears damaging trees on the Snoqualmie study area based on a comparison of incisor groove measurements from damaged trees with the average incisor widths of captured female and male black bears, Washington, 1996–1997

Incisor class	No. of trees	No. damaged by females (%)	No. damaged by males (%)	No. damaged by unknown gender (%)
I1	98	88 (89.9)	3 (3.1)	7 (7.1)
I2	73	66 (90.4)	0 (0.0)	7 (9.6)

Comparison of incisor grooves in cambium with classification ranges generated from cumulative distribution curves indicated that tree damage was primarily caused by female bears (Table 2). The I1 incisor analysis revealed female bears damaged 89.9% (88 of 98) of trees sampled. Damage by male bears was detected in 3.1% (3 of 98) of trees sampled. Analysis of the I2 incisors also indicated female bears caused most (90.4%, 66 of 73 trees) of the observed damage to trees (Table 2). Sample sizes were unequal for I1 and I2 incisor groove measurements because I2 grooves occurred less frequently in cambium due to the curvature of a bear's jaw.

4. Discussion

Female black bears are thought to cause the majority of feeding damage to trees for several reasons (Pierson, 1966; Flowers, 1987; Schmidt and Gourley, 1992). Black bear damage to forest stands coincides with the breeding season (May, June), when breeding males lose weight, presumably because of reduced feeding (Noyce and Garshelis, 1998) and breeding activity. Females may have high energetic requirements during spring due to the birth of cubs and lactation. The reduced food intake of breeding males and increased energetic demands on lactating females suggests that females may forage more intensively.

This study revealed female bears damaged the majority of trees sampled. Female bears did the majority of the damage even on damage plots associated with male telemetry locations (Stewart, 1997). Preliminary gender determination by DNA analysis from hair collected from freshly damaged trees also suggested female bears were associated with damaged trees (Stewart, 1997). This study also revealed that, while bears may use either upper and lower incisors to scrape trees, they predominantly used upper incisors. Other studies report bears use lower incisors predominantly (Maser, 1967) or both upper and lower incisors (Pierson, 1966).

Black bear tree damage control methods include experimentation with silvicultural practices to minimize bear foraging efficiency, supplemental feeding programs, and lethal removal of bears suspected of causing damage (Nolte et al., 1998; Ziegltrum, 1994; Witmer et al., 2000). Harvest data from controlled hunts in Washington show that males are predominantly killed (147 males and 87 females for which gender was known of 386 bears killed from 1995–98; Washington Department of Fish and Wildlife, 1995, 1996, 1997, 1998). Consequently, controlled hunts may not target bears causing tree damage.

Damage prevention and management practices should concentrate in areas with historical black bear damage as well as in those stands that show a potential vulnerability to bear depredation based on an assessment of key habitat variables (Stewart et al., 1999). Additionally, bear damage management should target the offending animals (Witmer and Whittaker, 2001). This will provide more efficient, integrated forest and wildlife management.

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